Amendments to the Specification

Kindly amend the specification as follows:

On page 8, replace the first full paragraph with the following:

The balancing cylinder 170 comprises a piston 172, which divides a cylinder cavity into an upper reservoir 171 and a lower reservoir 173. The housing 176 of the piston ~~170~~ 172 has a vent hole 175. Thus, when the piston 172 is slid a sufficient distance in the direction denoted by the arrow 1 in Figure 1, the vent hole 175 is located in the lower reservoir 173 so that the lower reservoir 173 is vented through the vent hole 175. The upper reservoir 171 has an aperture to which a first end of a first pipe 180 is connected. The lower reservoir 173 has an aperture to which a first end of a second pipe 181 is connected. The balancing cylinder 170 is further configured to accept a pipe 190 having a first end and a second end. The first end resides in the lower reservoir 173 and allows fluid communication between an outside source and the lower reservoir 173.

On page 9, replace the first full paragraph with the following:

Figures 2A-C illustrate a top view, a side cross-sectional side view, and a bottom view, respectively, of the plate 120. Figure 2A illustrates the plate 120 as viewed from the seal-energizing cavity 115. Figure 2A shows an outer face 135 of the plate 120, which forms a surface of the seal-energizing cavity 115. The outer face 135 has a radius 134 and a corresponding surface area. Figure 2B illustrates a cross-sectional side view of the plate 120. Figure 2B shows that a cross-section of the plate 120 has an inverted U-shape. Figure 2B indicates, by the arrow 132, a radius of an inner face 136 of the plate 120. The inner face 136 defines a surface of the processing volume (140, Figure 3) when the processing ~~system~~ assembly 100 is in a closed position. Figure 2B further shows the sealing face 130 and the sealing element 131 contained within a sealing groove on the sealing face 130, both described in more detail below. Figure 2C illustrates a bottom view of the plate 120, as seen from the processing volume 140, Figure 3. As illustrated in Figures 2A-C, the inner face 136 and the outer face 135 are opposing faces of the plate 120. Preferably, as depicted in Figures 2A-C, a surface area of the outer face 135 depicted by the radius 134 is larger than a surface area of the inner face 136

depicted by the arrow 132. In one embodiment, the inner face 136 and the outer face 135 are both substantially planar.

On page 9, replace the second full paragraph with the following:

It will be appreciated that while Figures 2A-C depict the plate 120 as circular, the plate 120 can have other shapes, geometrical and non-geometrical. Furthermore, while Figures 2A-C depict the sealing element 131 and thus its associated sealing groove (not shown) as circular and located on the plate 120, it will be appreciated that the sealing element 131 and its associated groove can have other shapes, both geometrical and non-geometrical, and can be located on other components in the processing ~~system~~ assembly 100. For example, the sealing element 131 and its associated groove can be located on the surface 156 of the lower component (150, Figure 1), on the platen (155, Figure 1), or at other locations.

On page 11 and continuing on page 12, replace the last full paragraph starting on page 11 and ending on page 12 with the following:

Figure 3 is again referred to, to explain the operation of one embodiment of the present invention. In operation, a semiconductor wafer (not shown) is placed onto the platen 155. The upper element 110 is brought into contact with the lower element 150, and the yoke arms 185A-B and 186A-B are positioned to tightly hold the upper element 101 to the lower element 150. Next, a sealing material such as an incompressible or nearly incompressible fluid, such as water, is introduced into the upper reservoir 171 of the balancing cylinder 170 and thus flows into the sealing cavity 115. It will be appreciated that other incompressible fluids, such oil, can be used as a sealing material. In addition, materials other than an incompressible or nearly incompressible fluid can be used in accordance with the present invention. It will also be appreciated that the incompressible or nearly incompressible fluid can be introduced at any time before processing, such as, for example, when the ~~semiconductor processing system~~ processing assembly 100 is in the open position.

On page 17, replace the second full paragraph with the following:

As described in more detail below, when the processing assembly 300 is in the open position, a semiconductor wafer is placed on the platen 306. A sealing material is then introduced into the seal-energizing cavity 410 to move the pedestal 305 and thus the platen 306 in the direction of the arrow 6. The processing ~~system~~ assembly 300 is now in the closed position. The pressure intensifier 908 can then be used to ensure that, while the semiconductor wafer is being processed in the processing volume 510, a processing volume seal (and thus the processing volume 510) is maintained. When processing is complete, the sealing material can be removed from the seal-energizing cavity 410 to move the processing ~~system~~ assembly 300 to the open position. The semiconductor wafer can then be removed from the platen 306. It will be appreciated that devices other than semiconductor wafers can be processed in accordance with the present invention.

On page 18, replace the second full paragraph with the following:

Once the processing assembly 300 is in the closed position, low-pressure CO_2 gas is introduced from the CO_2 supply vessel 360 into the low-pressure chamber 705. The CO_2 gas travels from the CO_2 supply vessel 360, through the pressure regulator 352, through the piping 901C, the air-operated valve 330, the piping 901A, and into the low-pressure chamber 705. The introduction of the CO_2 gas into the low-pressure chamber 705 exerts a force on the piston 310 which pushes the base 392 and thus the head 391 upward, in the direction of the arrow 6. Since the low-pressure water above the head 391 is isolated, it cannot flow out of the seal-energizing cavity 410. The low-pressure water becomes pressurized and pushes the head [[980]] 391 and thus the platen 306 upward, forcing the sealing element 520 against the surface 301 to maintain the processing volume 510.

On page 19 and continuing on page 20, replace the last full paragraph starting on page 19 and ending on page 20 with the following:

When processing within the processing volume 510 is complete, the processing assembly 300 is placed in the open position. This is accomplished by draining the low-pressure water in the seal-energizing cavity 410 through the piping 916 and 917, the air-operated valve 324, and out the drainage port 321. It will be appreciated that operation of the air-operated valves 323, 324, and 325 must be coordinated so that (a) low-pressure water is transferred from the water

supply vessel 320 and into the seal-energizing cavity 410 to place the processing assembly 300 in the open position, and (b) low-pressure water is transferred from the seal-energizing cavity 410 and out through the drainage port 321 to place the processing ~~system~~ assembly 300 in the closed position.

On page 22, replace the first full paragraph with the following:

The electronic ~~regulator~~ pressure controller 900 uses an external set point from the set-point signal source 909. The electronic pressure controller 900 sends a signal to the pressure regulator 902, which controls the intensifier pressure. As the intensifier pressure rises to ~~generated~~ generate a force to counterbalance the force generated by the processing pressure, a pressure signal from the pressure intensifier 908 is transmitted to the pressure regulator 901, causing the processing pressure to track the sealing pressure. The processing pressure is monitored by a pressure transducer 385 coupled to the electronic ~~regulator~~ pressure controller 900.

On page 23, replace the first full paragraph with the following:

The top plate 921 and the bottom plate 922 define a processing volume [[980]] 983 containing the platen 982. The top plate 921 has an inner surface 989 that forms part of the processing volume [[980]] 983. The platen 982 supports a workpiece such as a semiconductor wafer (not shown) undergoing processing within the processing volume [[980]] 983. The piston 965 has a head 962 with a face 9502. The head 962 is contained within an inner cavity 9501, as described below.

On page 23, replace the second full paragraph with the following:

The directional flow controller 966 comprises a check valve 963 and a needle valve 964. The pressure intensifier 975 comprises a low-pressure chamber 942, a high-pressure chamber 941, and a piston 943 coupling the low-pressure chamber 942 to the high-pressure chamber 941. The pressure intensifier 975 has an input 9750 coupled to the low-pressure chamber 942, and an output 9751 coupled to the high-pressure chamber 941. Similar to the pressure intensifier 908 of Figure 8, a low-pressure generated at the input 9750 is translated into a high-pressure generated

at the output 9751. In one embodiment, the ~~air-pressure controller~~ pressure regulator unit 944 comprises a MAC PPC93A, sold by TSI Solutions, 2220 Centre Park Court, Stone Mountain, Georgia 30087. In one embodiment, the filter 961 is a three-micron filter.

On page 24, replace the first full paragraph with the following:

As illustrated in Figure 11, the processing volume [[980]] 983 is coupled to the pressure transducer 931 and the differential pressure switch 932. A first input 9440 of the pressure regulator unit 944 is coupled to the pressure transducer 931, a second input 9441 of the pressure regulator unit 944 is coupled to an external set point 946, and a third input 9444 of the pressure regulator unit 944 is coupled to the compressed air supply 999. A first output 9442 of the pressure regulator unit 944 is coupled to the pressure relief valve 947 and to the atmosphere through a vent (not shown). A second output 9443 of the pressure regulator unit 944 is coupled to the input 9750 of the pressure intensifier 975. The pressure relief valve 947 is coupled to the input 9750 of the pressure intensifier 975 by piping, to which is also coupled the pressure transducer 934. The pressure transducer can thus be used to monitor the pressure between the air-operated valve 947 and the input 9750 of the pressure intensifier 975.

On page 24 and continuing on page 25, replace the last full paragraph starting on page 24 and ending on page 25 with the following:

Next, low-pressure oil is transmitted from the hydraulic fluid vessel 967, through the input of the air-operated valve 960, and into the seal-energizing cavity 9501 to close the processing chamber 920, as described above in relation to the processing assembly 300 of Figure 8. Next, a processing material, such as supercritical CO_2, is introduced into the processing volume [[980]] 983 to process the workpiece. The pressure within the processing volume [[980]] 983 (the processing pressure) is translated into an electrical signal by the pressure transducer 931. The electrical signal is transmitted to the pressure regulator unit 944, which generates a mechanical output signal, such as a corresponding pressure. In normal operation, the mechanical output signal is transmitted to the input 9750 of the pressure intensifier 975. The pressure intensifier 975 then generates a high pressure output on its output 9751. The high pressure output is transmitted through the directional flow controller 966 and to the seal-

energizing cavity 9501 to seal the processing chamber 920, as described above in relation to the processing assembly 300 of Figure 8.

On page 25 and continuing on page 26, replace the last full paragraph starting on page 25 and ending on page 26 with the following:

As a workpiece undergoes processing within the processing volume [[980]] 983, the processing pressure is translated by the pressure transducer 931 into an electrical signal transmitted to the pressure regulator unit 944. The pressure regulator unit 944 in turn, generates a low pressure, which is transmitted to the input 9750 of the pressure intensifier 975. The low pressure is approximately that pressure which, when transmitted to the input 9750 of the pressure intensifier 975 is translated to a high-pressure generated on the output 9751, generating a sealing force approximately equal to the processing force. In operation, the pressure regulator unit 944 compares the external set point 946 with an electrical (feedback) signal from the pressure transducer 931. If the external set point 946 is smaller than the feedback signal, then the pressure regulator unit 944 vents the pressure intensifier 975 to the atmosphere through the pressure relief valve 947. If the external set point 946 is larger than the feedback signal, then the pressure regulator unit 944 routes compressed air from the compressed air supply 999, to the input 9444 of the pressure regulator unit 944, through the output 9443, and into the input 9750 of the pressure intensifier 975. In this way, the sealing force is regulated to track the processing force.

On page 26, replace the second full paragraph with the following:

Other configurations in accordance with the present invention can also be used to efficiently maintain a processing volume, such as the processing volume [[980]] 983 in Figure 11, by exploiting a relationship between a processing pressure and a sealing force. One embodiment of the present invention uses a formula that relates a processing pressure to a sealing force and uses the formula to calculate the minimum sealing force. By limiting the sealing force to this minimum, a processing volume can be maintained by advantageously using the minimum energy required.

On page 26, replace the third full paragraph with the following:

It is believed that when (1) the first face of a plate and the second face of the plate have unequal cross-sectional areas, and (2) the difference between the pressure exerted on the first face and the pressure exerted on the second face is constant, then (3) the net force on the plate is not constant, but varies. Thus, for example, when a pressure P1 is exerted on a first face having a cross-sectional area A1, and a pressure P2 is exerted on a second face having a cross-sectional area A2, then the net force (ΔF) on the plate is given by Equation 1:

$$\Delta F = P1*A1 - P2*A2 \quad (1)$$

ΔF corresponds to the additional force on one side of the plate than on the other side of the plate. When a plate is perfectly counterbalanced, ΔF equals 0. It will be appreciated that when a plate is used to form a processing volume, by counterbalancing the plate (i.e., by keeping [[$\Delta F > 0$]] $\underline{\Delta F \geq 0}$), a processing volume is maintained. When ΔF is larger than 0, the processing volume is maintained using a greater force than is necessary, requiring extra, unneeded energy.

On page 26 and continuing on page 27, replace the last full paragraph starting on page 26 and ending on page 27 with the following:

Again referring to Equation (1), when A1 equals A2, ΔF equals A1*(P1 - P2)–that is, when the pressure difference P1 - P2, ΔP, is constant, ΔF is constant. If ΔP is not constant, then ΔF varies linearly with ΔP. When A1 does not equal A2, then the relationship between ΔF and ΔP is different, a relationship exploited by the present invention. Indeed, it is believed that the net force ΔF is not always proportional to the difference P1 - P2. Thus, for example, when A1 = 100 in^2, A2 = 200 in^2, P1=3,000 lb-f/in^2, and P2=1,600 lb-f/in^2, then the difference in pressure (P1-P2) or ΔP = 3,000 lb-f/in^2 - 1,600 lb-f/in^2 = 1,400 psid ("psid" denoting pounds per square inch differential). The net force, ΔF, then equals P2*A2 - P1*A1 = 1,600 lb-f/in^2 * 200 in^2 - 3,000 lb-f/in^2 * 100 in^2 = 20,000 lbf-d ("lbf-d" denoting pound force differential). When, however, P1=2,500 lb-f/in^2 and P2=1,100 lb-f/in^2, so that ΔP does not change (i.e., remains 1,400 psid), ΔF then equals P2*A2 - P1*A1 = 1,100 lb-f/in^2 * 200 in^2 - 2,500 lb-f/in^2 * 100 in^2 = -30,000 lbf-d. Thus, even though ΔP remains constant, when the pressure changes, ΔF can change magnitude and direction. It is believed that in a processing system, such as the processing system 600 in Figure 11, ΔF varies with the pressure within a processing volume

(P_{vol}), such as the processing volume [[980]] 983.

On page 27, replace the first full paragraph with the following:

As described below, embodiments of the present invention exploit this relationship to efficiently maintain a processing volume. Using the above example, when P1 increases, ΔF increases. Referring to Figure 11, P1 corresponds to the pressure within the processing volume [[980]] 983 (P_{vol}) and P2 corresponds to a sealing pressure (P_{seal}). Thus, when P_{vol} increases, and ΔP is kept constant, ΔF unnecessarily increases. ΔF (and thus P_{seal}) can be reduced to conserve energy, while maintaining the processing volume. This non-linear relationship (P_{seal} does not have to track P_{vol}) can be used to reduce the energy input into a processing system used to maintain a processing volume. Energy can be introduced into the processing system at, for example, the input 9444 of the ~~MAC valve~~ pressure regulator unit 944 of Figure 11.

On page 27, replace the last full paragraph with the following:

The discussion above and the graphs below describe a processing system in which a pressure differential ΔP is substantially constant. This limitation is used primarily to simplify the discussion. It can also be used to simplify the algorithms that control the ~~MAC valve~~ pressure regulator unit 944. It will be appreciated that ΔP can vary in accordance with embodiments of the present invention.

On page 28, replace the second full paragraph with the following:

Referring to Figure 11, the processing system 600 comprises a processing volume [[980]] 983. The processing volume [[980]] 983 is maintained by counterbalancing (1) a processing force exerted against a face 989 in the processing volume [[980]] 983 and (2) a sealing force exerted against the face 9502 of the hydraulic piston 965. ΔF corresponds to the additional force above that needed to maintain the processing volume [[980]] 983. In one embodiment, the face 9502 has a larger cross-sectional area than the cross-sectional area of the face 989. Preferably, the processing system 600 is configured to perform high-pressure processing. For example, the processing system 600 can be configured to introduce supercritical CO_2 into or generate supercritical CO_2 within the processing volume [[980]] 983. Preferably, the processing volume

[[980]] 983 is thus configured to withstand supercritical temperatures and pressures, and is coupled to a vessel for supplying supercritical materials, such as a CO_2 supply vessel.

On page 29, replace the first full paragraph with the following:

Table 1 lists some of the values used to plot the graph 1200 in Figure 12. Referring to Table 1, column 2, labeled "Processing Pressure," contains entries for P_{vol}. Column 3, labeled "Sealing Pressure," contains entries for P_{seal} sufficient to maintain the processing volume [[980]] 983. Column 1, labeled "MAC Pressure," contains entries for pressures generated by the ~~MAC valve~~ pressure regulator unit 944, which are translated into sealing pressures (P_{seal}) sufficient to generate a force sufficient to maintain the processing volume [[980]] 983. Column 4, labeled "ΔP," contains entries for the difference between corresponding entries in columns 2 and 3 ($\Delta P = P_{seal} - P_{vol}$). Column 5, labeled "Processing Force," contains entries for the force exerted on the face 989. Column 6, labeled "Sealing Force," contains entries for the force exerted on the face 9502. Column 7, labeled "ΔF," contains entries for the difference between corresponding entries in columns 5 and 6.

On page 29 and continuing on page 30, replace the last full paragraph starting on page 29 and ending on page 30 (prior to the listing of Table 1) with the following:

This relationship has two consequences. First, if there is a minimum force necessary to maintain a processing volume (i.e., maintain a processing seal), ΔP must be selected so that at the lowest pressure there is sufficient force to maintain the processing volume. In this case, as the pressure rises, the net force ΔF increases above this minimum level (ΔF_{thresh}), an inefficient process. Instead, the ~~MAC valve~~ pressure regulator unit 944 can be optimized so that P_{seal} is controlled so that ΔF never exceeds ΔF_{thresh}, thus using the minimum energy to maintain the processing volume. The second consequence is that, if the required sealing force (and thus P_{seal}) increases at a slower rate than the processing force (and thus P_{vol}), then P_{seal} can lag behind P_{vol} and still maintain the processing volume. Thus, the response time of the ~~MAC valve~~ pressure regulator unit 944 used to generate a sealing force need not be as fast as the changes in processing pressures.

On page 30, replace the paragraph which immediately follows Table 1, with the following:

Again referring to Figure 11, the ~~MAC valve~~ pressure regulator unit 944 can be controlled to follow the relationship given in Equation (1) above. For example, the ~~MAC valve~~ pressure regulator unit 944 can be programmed or coupled to a controller that controls the ~~MAC valve~~ pressure regulator unit 944 to efficiently vary P_{seal} (and thus the sealing force) in accordance with the present invention. The ~~MAC valve~~ pressure regulator unit 944 can be programmed to generate a pressure that is ultimately translated into the required P_{seal} and thus translated into the sealing force, as described above.

On page 30 and continuing on page 31, replace the last full paragraph starting on page 30 and ending on page 31 with the following:

The ~~MAC valve~~ pressure regulator unit 944 can also be controlled so that ΔF never falls below a threshold value, ΔF_{thresh}. ΔF_{thresh} can correspond, for example, to a force differential that allows for small pressure swings and thus ensures that a processing volume is maintained even if the ~~MAC valve~~ pressure regulator unit 944 is slow to increase P_{seal} in response to changes in P_{vol}. It will be appreciated that the ~~MAC valve~~ pressure regulator unit 944 must be configured to switch between pressures quickly enough to constantly maintain the processing volume [[980]] 983.

On page 31, replace the first full paragraph with the following:

Figure 14 shows sealing steps 1400 in accordance with one embodiment of the present invention. In the first step 1401, the start step, any initialization steps are performed. Referring to Figure 11, in the first step 1401 a wafer is placed on the platen 982 and the processing volume [[980]] 983 is formed. Other initialization steps can include determining the maximum processing pressure that will be attained within the processing volume [[980]] 983, calculating other processing parameters, etc. Next, in the step 1402, it is determined whether a minimum force differential (ΔF_{thresh}) is needed to maintain the processing volume [[980]] 983. If a minimum force differential is necessary, step 1410 is performed; otherwise, step 1405 is performed.

On page 31, replace the third full paragraph with the following:

In the step 1415, a wafer is processed within the processing volume [[980]] 983. Next, in the step 1420, P_{vol} and P_{seal} are read and P_{seal} is varied to maintain the processing volume [[980]] 983. In accordance with one embodiment of the present invention, P_{seal} is varied in accordance with Equation (1) above to efficiently maintain the processing volume [[980]] 983. That is, P_{seal} can be set to lag P_{vol} and still maintain the processing volume [[980]] 983 by ensuring that $\Delta F > \Delta F_{thresh}$. It will be appreciated that while, for simplicity, Figure 14 shows the step 1420 being performed after the step 1415, it will be appreciated that the step 1420 will be performed during the step 1415, that is, while a wafer is being processed.

On page 31 and continuing on page 32, replace the last full paragraph starting on page 31 and ending on page 32 with the following:

Next, in the step 1430, it is determined whether processing of the wafer is complete. If processing is not complete, the step 1420 is performed again. If processing is complete, the step 1435 is performed. In the step, 1435, the processing volume [[980]] 983 is returned to non-processing conditions, the processing volume [[980]] 983 is broken, and the wafer is removed from the platen 982. Next, in the step 1440, the processing steps are complete.

On page 32, replace the first full paragraph with the following:

As described above, P_{seal} can be controlled by the ~~MAC valve~~ pressure regulator unit [[940]] 944, which can be programmed to perform the step 1420, in accordance with the present invention. As described above, the ~~MAC valve~~ pressure regulator unit 944 can be programmed or otherwise controlled to generate a pressure that is translated into a sealing force as described in Equation (1) above.